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NOTICE.

Any person on the mailing list of the PUBLIC HEALTH REPORTS who, at any time, fails to receive promptly this publication will confer a favor by notifying the Surgeon-General of the United States Marine-Hospital Service.

UNITED STATES.

THE POLLUTION OF STREAMS AND THE PURIFICATION OF PUBLIC WATER SUPPLIES.

[Comparative merits of sand and mechanical filters.(a) By George M. Kober, M. D., Professor of Hygiene, Medical School, Georgetown University, Washington, D. C.]

COMPOSITION OF RIVER WATER.

River water is a mixture of spring, ground, rain, and surface water, but as the water courses are the natural drainage channels of the country, it is not surprising that the wastes of human life and occupation should also find their way into the streams. It is for this reason that rivers, after passing through cultivated valleys with cities, towns, and villages or settlements on their banks, often contain a dangerous amount of mineral and organic matter. Rivers are always purer near their source; the amount of impurities increases as we descend the stream. Thus, for example, the Mississippi River at Minneapolis contains only 18.6 total solids per 100,000, while the same river at St. Louis contains 244.3 per 100,000.

RIVER POLLUTION.

The sanitarian recognizes two principal forms of pollution, viz: The amount of mineral matter, and, second, the character and amount of organic matter contained in the water. The amount of mineral matter depends largely upon the geological formation of the country and the

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[a] Read before the Section of State Medicine, American Medical Association, June 5, 1900.

erosive powers of the streams, but water containing 50 parts per 100,000 or 30 grains of solid matter per gallon is unfit for drinking purposes on account of its irritating effects upon the gastro-intestinal tract. Beyond this, however, it is of no special significance, unless the water also contains metallic poisons or objectionable chemicals.

In regard to the Potomac River, which may serve as a type of American rivers for our discussion, we know, for instance, that certain pulp mills, tanneries, and manufacturing establishments discharge chemicals and various refuse; one paper mill alone discharges over 100,000 gallons of liquid into the river each day heavily laden with sulphuric and tannic acids.

These gross forms of pollution, although at times so great as to prove destructive to game fish, are of less interest to sanitarians than pollution with organic matter, especially sewage contamination derived from the towns and settlements within the Potomac drainage basin, which covers 11,043 square miles, with an estimated population of 491,813 people, or about 44.5 per square mile.(*a*) Among the larger towns may be mentioned Cumberland, Frederick, Hagerstown, Harpers Ferry, Staunton, but as none of them are sewered, whatever contamination they produce is derived from surface drainage.

CHEMICAL ANALYSES.

Notwithstanding these numerous sources of pollution, the Potomac River, according to the chemical analyses, compares very favorably as regards purity with other American rivers.

The following are the results tabulated for comparison by Colonel Miller and based upon 72 analyses of the Potomac water as delivered from the faucet in the laboratory of the health office from July, 1897, to January 31, 1900, and daily analyses made by Mr. R. S. Weston between July 1, 1899, and January 20, 1900:

	Total solids.	Free ammonia.	Alb. ammonia.	Nitrites.	Nitrates.	Chlorine.	Required oxygen.
Health office............	126.7	0.0008	0.111	Trace.	0.639	3.78	2.56
Robert S. Weston....	139.0	.013	.105	0.002	.73	2.60	4.50
Mason's safe limit...	150-300	.01-.12	.10-.28	.0135-.003	.42	3.10	5-7.

BACTERIOLOGICAL ANALYSES.

Now, let us inquire into the results of the bacteriological examinations of this water which have been made by various competent authorities at the Army Medical Museum, and by Kinyoun and Sprague, of the Marine-Hospital laboratory, during the past ten years. The latter also examined samples at or near all the important towns from the head waters of the Potomac and Shenandoah rivers, and may be said to accurately represent the bacteriological condition of the entire river. Intestinal organisms were found in over 90 per cent of the samples. The number of bacteria varied from 150 to 20,000 per cubic centimeter, with an average of something over 1,000. The more recent examinations, conducted under the supervision of Colonel Miller from July, 1899, to March, 1900, show a minimum per cubic centimeter of 48 in July and a maximum of 51,000 for January, 1900, with an average of 3,761 per cubic centimeter. Of the specimens taken on about two

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a See Colonel Miller's report, Senate Doc. 259, p. 9.

hundred different days, 50 per cent, or one-half, revealed the presence of the bacillus coli communis.

TURBIDITY AND BACTERIA.

This exhaustive study also confirmed the conclusions of Theobald Smith and others, that turbidity of the Potomac water is always accompanied by a larger amount of organic matter and germs, and that fecal bacteria and turbidity are coincident, simply because the same showers that bring along large sections of pulverized river banks also wash through the towns, barnyards, cesspools, and outhouses before finding their way into the creeks and river.

SIGNIFICANCE OF INTESTINAL BACTERIA.

The presence of intestinal bacteria is satisfactory evidence of pollution by fecal matter of man or animals and strongly points to the possibility of infection with typhoid bacilli.

Mr. Davis, of the Geological Survey, estimates that the sewage from the vicinity of Cumberland, a distance of about 134 miles, requires from two to four days to reach the Washington aqueduct. We also know that typhoid bacilli retain their vitality for a number of days in ordinary water, and could, therefore, infect consumers of water in Washington.

TYPHOID FEVER AND WATER-BORNE DISEASES.

My suspicions that typhoid fever germs may thus travel all the way from Cumberland were confirmed as early as the winter of 1889–90 by studying the effects of the typhoid fever epidemic at Cumberland upon the prevalence of the disease in Washington.

The records of the health office show that during this epidemic, from December, 1889, to April, 1890, the deaths from typhoid fever amounted to 74, as compared with 42 for the corresponding months of the previous year. Indeed, we had almost double the number of typhoid deaths during these months than for any similar period either before or since this epidemic.

Cumberland had about 45 deaths and 485 cases. Washington had 74 deaths and about 740 cases; and yet the starting point of all was the excreta of one patient washed into a little run which empties into the Potomac about 300 feet above the pumping station of the water supply for Cumberland. In the face of this fact and the almost constant presence of intestinal bacteria, I have no hesitation in declaring that the excessive typhoid fever rate of the national capital is largely due to contaminated Potomac water. We know the germs must be there, whether the bacteriologists find them or not, because the people who drank the water were taken sick, while nonconsumers remained exempt.

What has been said of the Potomac River is equally applicable to the Ohio, Mississippi, Merrimac, Connecticut, Missouri, and other American rivers, because they are the sewers and at the same time the source of water supply for nearly all the cities located upon their banks, and these cities, as shown by the statistics collected by the Marine-Hospital Service, show, moreover, a marked prevalence of typhoid fever, thus confirming what has been observed over and over again that this disease, as also cholera, dysentery, and diarrheal diseases, can be carried from one town or city to another by means of a water course.

About three years ago Surgeon-General Wyman estimated, from statistics received in his office, that every year there are no fewer than 45,000 deaths caused by typhoid fever alone throughout the United States. This number has now reached, very likely, 50,000, and, based upon an estimated mortality of 10 per cent, it is within reason to assume a yearly prevalence of 500,000 cases of this disease.

The average duration of a case is not less than thirty days. If we calculate that only $1 per day is expended for care, treatment, and loss of work and that the value of a human life is $5,000 we have a total loss in the United States every year of $400,000,000 from one of the so-called preventable diseases. Reduce the prevalence of this single disease one-half, which has been accomplished in Europe and can be done here, and the question as to what public sanitation has accomplished will be answered from an economic point of view.

We would not think of establishing a vicious circle between our mouths and the drainage of our houses and stables, and yet practically we have suffered this to be done upon the erroneous assumption that rivers purify themselves. While a certain degree of purification is possible by natural means, such as dilution with unpolluted water, deposition of suspended matter, the agency of aquatic animals and plants, the bacteria of nitrification, the destructive influence of sunlight upon microorganisms, and the chemical affinity of certain bodies, I am glad that biologists have about come to the conclusion that "no river is long enough to purify itself."

What has been said of typhoid fever is equally true of other water-borne diseases like cholera, dysentery, cholera morbus, diarrheal diseases, and the transmission of the eggs of intestinal and other parasites, because the germs or eggs of these diseases are present in the intestinal tract and presumably also in sewage-contaminated water. Thus. for example, the cholera epidemic at Hamburg in August, 1892, resulting in 17,020 cases, with 8,605 deaths, was caused by a band of gypsies camped on the banks of the river Elbe, and the discharges of one of its members suffering from cholera were emptied into the river, which at that time was served to the inhabitants of Hamburg without filtration. The epidemic spared the adjoining city of Altona, which derives its water from the same river after receiving the sewage of Hamburg, with its 800,000 people, but Altona filtered its water and Hamburg did not.

PREVENTION OF RIVER POLLUTION.

When we remember that the general mortality of London a century ago was still 40 per 1,000, while at the present time it is between 20 and 21 per 1,000, and that no two factors have contributed so much to the prolongation of human life as the improvement of the air we breathe and the water we drink, it must be apparent that it is high time for civilized communities to take steps toward removing the danger to be found in rivers which are the sewers and at the same time the sources of public water supplies. "One of the most pressing needs, therefore, is an investigation into the pollution of water supplies, when such pollution effects or threatens to effect the sanitary condition of the people of more than one State," because the individual States are powerless to protect themselves against the misdeeds of their neighbors.

Mr. Bartholett's bill for the appointment of a river pollution commission, first introduced five years ago, has not yet become a law. England enjoyed the benefit of such a commission as early as 1855, and in order to prevent, remedy, and remove the danger of polluted water supplies adopted a comprehensive system for the disposal of sewage and of water filtration, the fruits of which are shown by a marked decrease in the number of cases of typhoid fever, diarrheal diseases, and consumption, amounting in some localities to over 50 per cent.

I maintain that no community or individual has a right to pollute streams used for public water supplies any more than a man has to contaminate his neighbor's well. This principle is very well appreciated by some of the nations in Europe. Thus the inhabitants of a town in Belgium suffered from the effects of a river polluted by the French, and the French Government not only compelled the offending city to dispose of its sewage by irrigation, but granted a subsidy for this purpose.

All that is needed in this country is a correct appreciation of the dangers, and the first step in this direction is the appointment of a commission. The Marine-Hospital Service, which has for a number of years satisfactorily performed the functions of a national board of health, could, with the aid of the hydrographers of the Geological Survey and special agents of the Department of Agriculture, perform this duty without any great expense to the Government.

PURIFICATION OF SEWAGE BY IRRIGATION.

After determining the extent and dangers of river pollution, the remedy can be applied, and consists in the adoption of a system in which the sewage and noxious waste waters are utilized and disposed of by irrigation on so-called sewage farms, and the effluent and purified waters are returned to the stream.

This system has been in vogue in some European cities for many years. The city of Berlin purchased about 20,000 acres of land and, notwithstanding the enormous outlay of a little over $3,000,000 for the land and over $10,000,000 for the sewer system, operates these farms at a net profit of about $60,000 per annum. The city employs men condemned to the workhouse as laborers at the farms and practically converts vagabonds into producing classes, with a fair prospect, too, that many of these individuals will continue their honest efforts to become self-supporting citizens; moreover, the old manor houses of the individual farms are utilized as country homes for convalescents, and thus the beneficent effects of this system are felt in more than one direction.

It is a matter of great satisfaction, therefore, that within the past ten or twelve years over one hundred communities in the United States have established plants for the disposal of sewage. The first attempt in the establishment of a sewage farm in this country was made at the Augusta, Me., State Insane Asylum in 1872, since which time 78 plants for the disposal by irrigation and 15 by chemical treatment, etc., have been established, and over 40 more projected. I have prepared Table No. 1 from data obtained in Mr. George W. Rafter's Brochure No. 22 of the United States Geological Survey, 1899, on Water Supply and Irrigation. Among the more prominent and successful sewage farms may be mentioned Brockton and South Framingham, Mass.; Bristol, Conn.; Plainfield, N. J.; Altoona and Wayne, Pa.; Pullman, Ill.; Hastings, Nebr.; Colorado Springs, Colo.; Salt Lake City, Utah; Helena, Mont.; Phœnix, Ariz.; Fresno, Los Angeles, Pasadena, Redding, and Santa Rosa, Cal.

Disposal of sewage by land treatment.

Name of place, town, or city.	Population.	When established.	Number of acres.	Remarks.
Far Rockaway, N. Y	2,288	1895	...	Broad irrigation.
Hemlock Lake, N. Y	1,000	1896	...	Pail system.
Vassar College, N. Y.	...	1895	Several.	Broad irrigation.
Atlantic City, N. J	13,000 to 150,000	...	...	Filtration [not efficient]; no attempts to raise crops.
East Orange, N. J	13,282	1888	...	Chemical treatment supplemented by filtration; no attempts to raise crops.
Essex Falls, N. J	...	1897	...	Filtration.
Freehold, N. J	2,932	1893	16	Broad irrigation, 16 acres in Hungarian grass.
Lawrenceville School, N. J.	...	1893	...	Broad irrigation and intermittent filtration.
Morris Plains Asylum, N. J.	...	1897	...	Sedimentation and subsurface irrigation.
Plainfield, N. J	13,000	1895	...	Broad and intermittent filtration [corn crops].
Princeton College, N. J.	...	...	4	Broad and intermittent filtration.
Summit, N. J	3,502	1892	26	Do
Westfield, N. J	3,000	1897	12	Broad and intermittent filtration and broad irrigation.
Altoona, Pa	30,337	1897	70	Irrigation; corn crops.
Norristown Insane Asylum, Pa.	1,500	1885	...	Broad irrigation; 5 crops of grass annually.
Wayne	997	1891	11	Broad irrigation; 5 crops of grass annually.
Weston State Insane Asylum, W. Va.	...	1891	27	Chemical precipitation supplied by broad irrigation.
Paris, Tex	8,254	1897	10	Intermittent filtration; alfalfa crops.
San Antonio, Tex	36,673	1895	530	Irrigation; contemplate farming.
Fostoria, Ohio	2,070	1895	...	Land purification.
Oberlin, Ohio	4,376	1893	15	Broad irrigation.
Pullman, Ill	11,000	1881	1,500	Sewage farm yields a net profit of $8.10 per acre.
Rochester Insane Asylum, Minn.	1,050	1890	...	Chemical precipitation, supplemented by intermittent filtration.
Hastings, Nebr	13,584	1892	20	Sewage farm.
Colorado Springs	11,140	1889	35	Sewage farm; 15 acres in alfalfa, 10 acres vegetable.
Trinidad, Colo	5,523	1892	...	Sewage farm; blue grass.
Helena, Mont	13,134	1889	40	Sewage farm; vegetables and nursery stock.
Salt Lake City, Utah	44,843	1896	183	Sewage farm; 80 acres in cultivation.
Phœnix, Ariz	3,153	...	160	Sewage farm; garden truck.
Fresno, Cal	10,818	1890	80	Do.
Los Angeles, Cal	50,395	1895	2,200	Sewage farm; grain, orchard, alfalfa, vegetable.
Pasadena, Cal	4,882	1893	300	Do.
Redding, Cal	1,821	1889	100	Sewage farm; corn, potatoes, vegetable.
San Luis Obispo, Cal	2,995	1888	...	Broad irrigation.
Santa Rosa, Cal	5,220	1889	18	Farm for vegetables.
Augusta, Me., State Insane Asylum.	...	1872	Few.	Produces hay and garden crops.
Concord, N. H., State Insane Asylum.	...	1872	Few.	Pumped to the irrigated area for crops.
Amherst, Mass	4,512	1881	...	Settling banks and absorption ditches; 3 heavy crops of hay raised annually.
Brockton, Mass	27,294	1894	30	Crops of pease, beans, tomatoes, corn, cabbages, etc.
Gardner, Mass	8,424	1891	2	Intermittent filtration; no farm.
Greenfield, Mass	5,252	1882	...	Meadow irrigation.
Lenox, Mass	2,889	1876	1½	Subsurface and surface irrigation; no farm.
Marlboro, Mass	13,805	1893	37	11 acres used for farming purposes.
Concord Reformatory, Mass.	...	...	...	Irrigation; grass and corn crops.
Medfield, Mass	1,493	1886	1	Sedimentation and upward filtration.
Natick, Mass	9,818	1896	12	Filtration.
Norfolk County Jail, Mass.	...	...	...	Land disposal plant; no details.
North Brookfield, Mass	8,747	1893	20	Broad irrigation; good crops.
Pegan Brook, Mass	...	...	4	Filtration.
Waltham School, Mass	...	...	...	Intermittent subsurface irrigation.
Sherborn Prison, Mass	...	...	...	Subsurface irrigation.
South Framingham, Mass.	...	...	...	Indian corn, crops standing sold for $30 to $40 per acre.
Wellesley College, Mass.	500	1893	1.55	Intermittent filtration.
Westboro, Mass	5,195	1892	33	One half of the land classed as swamp and meadow.
Worcester Insane Asylum.	...	...	30–40	About 14 acres used for farming purposes.
Central Falls, R. I.	20,355	1892	35	Filtration.
Pawtucket, R. I	32,577	1893	4	Do.
Cranston State Institute, R. I.	...	1895	500	Irrigation.

Disposal of sewage by land treatment.—Continued.

Name of place, town, or city.	Population.	When established.	Number of acres.	Remarks.
Bristol, Conn	7,382	1893	80	Broad irrigation and intermittent filtration; 6 acres in use.
Danbury, Conn	16,552	1897		Intermittent filtration.
Lake Wauremaug, Conn				Dry-earth system and fluid waste by filtration.
Litchfield, Conn	3,304	1890	4	Irrigation.
Meriden, Conn	21,652	1891	150	Broad irrigation and intermittent filtration; no attempt at farming.

Disposal of sewage by chemical and patented processes.

Name of place, town, or city.	Population.	When established.	Remarks.
Rockingham County Poor Farm, New Hampshire.	1,000	1895	Collecting tanks, sludge utilized for compost; patented process owned by the Glover Company.
Mystic Valley, Mass		1887	By chemical precipitation.
Worcester, Mass	98,678	1890	Chemical purification works.
Danbury, Conn	16,552	1897	Wolf's disinfecting process with sodium hypochlorite; recently purchased land for intermittent filtration.
Brewsters, N. Y		1893	Electrical treatment, simply a process of disinfection by sodium chloride; hypochlorite produced by electrolysis.
Brooklyn, Twenty-sixth Ward, N.Y.			Chemical purification; J. J. Powers's patent.
Chautauqua Assembly, N.Y.	(*a*)	1893	Chemical precipitation.
New Rochelle, N. Y	8,217	1894	Chemical purification.
Bath Soldiers and Sailors' Home, New York.	1,500		Chemical purification. Powers's patent.
Batavia State Institution for the Blind, New York.		1891	Chemical purification.
Long Branch, N. J	7,000-8,000 80,000-100,000	1886	Chemical precipitation and mechanical separation.
Reading, Pa	58,661	1895	Proprietary process.
Alliance, Ohio	6,707	1899	Chemical purification.
Canton, Ohio	26,189	1893	Do.
Wayne County Poor Farm		1896	Chemical precipitation.

a Several thousand.

Heretofore it has not been considered necessary to prevent the pollution of rivers affected by tide waters. Dr. Conn, of the Wesleyan University, in 1894, traced, however, an outbreak of typhoid fever to raw oysters which had been fattened in a place where they were liable to contamination by sewage from typhoid patients, and since then numerous instances have been reported elsewhere. It has been shown that typhoid fever germs remain viable in oysters from fourteen to thirty days, and the medical officer of the local Government board of England, in the twenty-fourth annual report, points out the danger of many of the oyster beds on the English coast from sewage pollution, all of which indicates that even this newly discovered source of danger should be guarded against.

PURIFICATION OF PUBLIC WATER SUPPLIES.

[Comparative efficiency of sand and mechanical filters.]

The primary object of disposing of sewage by means of irrigation is the prevention of the so called water-borne diseases. I do not believe, however, that this method alone can be relied upon, as instanced by the cholera epidemic at Hamburg and typhoid fever epidemics at Plymouth and Cumberland, where the dejecta of a single patient were sufficient to cause the mischief, hence prevention of river pollution should be supplemented by filtration of the water supply on a large scale, of which there are 2 systems, the American or mechanical system, and the English or natural sand filtration.

Time will not permit me to enter into their respective merits except to say that the mechanical filters, as first pointed out by Mr. Hill, have accomplished very little in the reduction of typhoid-fever death rates in cities where they are used. In the subjoined table 5 American cities using these mechanical devices are compared with 5 cities in Europe using water from sand filters, with an average for the year 1895 for the American cities of 46.8 typhoid deaths per 100,000 living, against 6 deaths per 100,000 for the foreign cities. That is to say, the American rate was almost 8 times greater than the foreign rate.

Europe (sand filtration).

	Before filtration.	After filtration.
Berlin	100	5
Breslau	113	9
Hamburg	21	9
Rotterdam	......	2
The Hague	......	5
Average	78	6

United States (mechanical filters).

Davenport	26
Atlanta	43
Chattanooga	48
Quincy, Ill	58
Knoxville	59
Average	46.8

Lest this comparison between foreign and domestic cities be considered unfair, I have prepared Table No. 3, showing the average number of deaths from typhoid fever in several American cities before and after filtration. From this table we learn that while sand filters accomplished a reduction of 78.5 per cent in the number of deaths from typhoid fever, the mechanical filters actually produced an increase of 20.43 per cent; and even if we eliminate from our consideration Elmira, Lexington, and Newcastle, where an increase was noted, the reduction of typhoid fever in consequence of mechanical filtration amounts to only 26 per cent, as compared with 78.5 per cent by the process of sand filtration.

TABLE 3.—*Showing the average number of deaths from typhoid fever per annum before and after filtration.* (*a*)

Sand filters.

Name of town.	Average number of deaths from typhoid fever per annum before filtration.	Average number of deaths from typhoid fever after filtration.	Reduction.	Number of years upon which statistics are based before and after filtration.	Remarks.
			Per cent.		
Lawrence, Mass	52	13.8	73.5	5	Filter established September, 1893.
Ashland, Wis	39	4.5	88.5	2	Filter established September, 1895.
Hamilton, N. Y	0.66	0.33	50	3	Filter established in 1896.
Mount Vernon, N. Y.	3.4	1.8	47	5	Filter established in 1894.
	95.06	20.43	78.5	....	
Mechanical filters.					
Macon, Ga	10.5	7	33	4	Filter established in 1893.
Atlanta, Ga	61	46	25	3	Filter established in 1881.
Oakland, Cal	19	17	11	5	Filter established (Hayatt), 1892.
Reading, Mass	4	1	75	1	Filter established (Warren), July, 1896.
Terre Haute, Ind	21.6	15	31	5	Filter established (National filter), July, 1890.
Elmira, N. Y	10	11	Increase. 10	1	Filter established April, 1898.
Newcastle, Pa	13	28	115	1	Filter established (New York), April, 1897.
Lexington, Ky	18	64.2	256	4	Filter established June, 1895.
	157.1	189.2	Increase, 20.43 prct.	....	

a This table is based upon an investigation undertaken by a committee of the medical society of the District of Columbia, which is not yet complete.

Plague in San Francisco.

[Continued from PUBLIC HEALTH REPORTS, No. 24, page 1475.]

[Telegrams.]

WASHINGTON, D. C., *June 14, 1900.*

Wire on what ground the habeas corpus was granted in the case of the quarantined Chinaman. Also has the correspondence in PUBLIC HEALTH REPORTS of June 1, showing plague in San Francisco and approval of President for making regulations, been submitted in evidence. Wire whether this is not considered by the court sufficient evidence of the satisfaction of the President that the plague exists as contemplated in the law of 1890. If court raises quarantine, immediately wire grounds given for this action.

KINYOUN, *San Francisco, Cal.* WYMAN.

SAN FRANCISCO, CAL., *June 15, 1900.*

Claims in habeas corpus case that Chinese had been caught in quarantine lines, only been Chinese quarter one hour, had not had plague, nor was suffering from plague. Judge De Haven granted discharge.

* * * The quarantine officer claimed probable exposure could not not substantiate. * * * KINYOUN.

The SURGEON-GENERAL, *U. S. Marine-Hospital Service.*